SOIL INVESTIGATION
SALT LAKE SUBDIVISION
HONOLULU, OAHU, HAWAII

1-1-63:3

H-LA Job No. 3992,001,06

Prepared for

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by

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September 9, 1974

INTRODUCTION

This report presents the results of the soil investigation we performed for a planned subdivision in the Salt Lake area of Honolulu, Hawaii. The site is adjacent to the Salt Lake Shopping Center on Salt Lake Boulevard. The preliminary Site Plan is shown on Plate 1.

The planned development will include one- or two-story residential units plus access roads. We anticipate that the buildings will be of wood frame construction with slab-on-grade floors. Site grading plans are not completed, but in general the site will be developed by using material excavated from the hillside area as fill to create level building sites and roadways. We understand planned cut heights are less than 35 feet and fill heights less than 20 feet.

The scope of our work, as outlined in our proposal dated July 5, 1974, was to develop conclusions and recommendations regarding

1. Site preparation and grading, including
   a. Maximum cut and fill slopes and slope heights
   b. Suitability of on-site material for fill
   c. Criteria for fill placement and compaction
2. Building foundation support, including foundation type and criteria necessary for foundation design
3. Settlement behavior of buildings and fill
4. Pavement design criteria for new roadways.

INVESTIGATION

Field Exploration

We explored subsurface conditions at the site with three test borings and three test pits at the locations shown on Plate 1. Our geologist logged the borings and pits and obtained undisturbed core samples of the materials encountered for examination and laboratory testing. The logs of the borings and pits are presented on Plates 2 through 6. The soils are classified in accordance with the Unified Soil Classification System explained on Plate 7.

In addition to on-site exploration our geologist examined nearby cuts made in rock similar to that found on the site.

Laboratory Testing

We tested selected samples in our laboratory to determine moisture content and dry density, shear strength, plasticity and compaction characteristics. The results except for the compaction test are presented on the boring logs. Shear strength results are described by the Key to Test Data, Plate 7. The plasticity test results also are presented on Plate 8. The compaction test results are presented on Plate 9.

SITE AND SOIL CONDITIONS

Site Conditions

The lower one-third of the site is nearly level; it slopes at about 10 percent from the east to the west. The upper two-thirds of the site is a hillside that slopes at about 30 percent. The hill-side slope begins to flatten near the western property line.

An abandoned church and two other wood frame buildings are located in the lower area. Concrete, wood and other debris have been dumped near the south property line at the location shown on Plate 1. The ground cover is sparse grass in the lower area and heavy grass and brush in the hillside area.

Soil Conditions

Fill blankets the lower part of the site; the approximate limits are shown on Plate 1. The maximum depth is about eight feet at the southeast corner and becomes progressively thinner to the northwest. The placement and compaction of the fill was probably not controlled and therefore, it probably is not of uniform density. Samples of fill obtained from the test borings were strong, of low compressibility and slightly expansive. The fill is underlain by weathered and fractured tuff bedrock.

The hillside is covered with a thin soil mantle over tuff bedrock. The bedrock is exposed as outcrops in many places. Bedrock encountered in the borings and test pits was deeply weathered and intensely fractured.

Ground water was not encountered to the depths explored.

CONCLUSIONS AND DISCUSSIONS

Excavation

The hillside excavation will be mostly in bedrock. We judge that the rock can be ripped by heavy duty equipment. Much of the excavated rock will be boulder size (greater than 12 inches); it probably will require crushing by heavy equipment or other means to produce sizes suitable for use as compacted fill. We expect that some of the excavated rock, probable less than ten percent, will be too hard to break-up and too large to use in the fill.

Cut Slope

Nearby cut slopes in tuff bedrock vary from about one-half horizontal to one vertical (1/2:1) to 1:1. Most of the cuts appears stable but show some minor rock sloughing. There is a major slide in one section of a nearby cut. Based on the performance of these cuts and the rock conditions revealed on the site, we believe a cut slope slightly flatter than that allowed by the City and County grading ordinance should be used. We recommend slopes of 3/4:1 or flatter with an eight foot wide level bench at mid-height for slopes greater than 15 feet high. We suggest that our geologist inspect the slope during excavation to assist in detecting local areas that may require modification from the general criteria presented in our recommendations.

Debris

The stockpile of debris contain wood and large pieces of metal pipe. These materials are not suitable as fill; they should be removed from the site. The asphalt concrete and concrete pieces smaller than 12 inches in maximum size can be used in the lower levels of the fill (below four feet).

Settlement

Settlement will result from compression of the existing fill under the weight of new fill loads. We estimate settlements will be less than one inch for 20 feet of new fill. Most of this settlement should occur during fill construction.

Settlement under new building loads should also be small; say less than one-half inch in fill areas and negligible amounts in rock cut areas.

RECOMMENDATIONS

Grading

The areas to be graded should be cleared of trees, shrubs, and debris. The upper three to four inches of soil should be stripped to remove grass, roots and other vegetation. This material is not suitable for use as compacted fill. The foundations for existing buildings should be removed where they will interfere with the placement of fill.

The existing fill in building and pavement areas should be excavated to the depth required to allow at least three feet of compacted fill below footings, floor slabs and pavement subgrades.

All areas to receive fill should be scarified to a depth of six inches, moisture conditioned and compacted to at least 90 percent relative compaction.* Fill material should then be spread, moisture conditioned, and compacted to meet the same requirement.

Fill shall be benched into existing slopes by cutting and maintaining a one foot minimum vertical cut against which fill will be placed.

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* Relative compaction refers to the dry density of the compacted material expressed as a percentage of the maximum dry density of the same material as determined by the ASTM D1557-70(C) procedure.

Fill material should be free of organic matter and debris, with the exception that asphalt and concrete chunks less than 12 inches in maximum dimension can be used in the lower fill lifts. Rocks larger than 12 inches in maximum dimension should be broken up or not used in the fill. The upper four feet of fill should not contain rocks larger than 6 inches in maximum dimension. Rocks should be well distributed in the fill so that they are completely surrounded by fine grained material. Fill placed within three feet of floor slabs and pavement subgrade should be nonexpansive. Although we believe that most of the on-site soil meets this requirement, soil placed within this zone should be tested during fill placement to confirm that it is nonexpansive.

Cut slopes in bedrock less than 35 feet high should be sloped at 3/4:1 or flatter. We should review this criteria if higher cut slopes are contemplated. Eight foot wide level benches should be constructed at mid-height for slopes over 15 feet high. A typical cut slope cross section is shown on Plate 1. Tops of cuts will be in native soil; they should be rounded to approximately 2:1.

Fill slopes less than 20 feet high will be stable at slopes as steep as 1-1/2:1. Our opinion is that fill slopes less than 20 feet high constructed of rocky fill will not require an intermediate bench for stability or erosion control.

Surface drainage should be provided to prevent ponding near the top of cut and fill slopes.

Foundations

Foundation support for the planned buildings can be obtained from conventional spread footings bottomed either in bedrock or in properly compacted fill.

Spread footings should be bottomed at least 12 inches below the lowest adjacent ground surface. Spread footings can be designed using the following criteria:

Allowable bearing pressures	Footings bottomed in bedrock	Footings bottomed in compacted fill
Dead plus reduced live loads . . .	4,000 psf	2,000 psf
Total design loads including wind or seismic forces	5,000 psf	3,000 psf
Resistance to Lateral Loads		
Friction on the bottom of footings (times vertical dead loads)	0.5	0.4
Passive soil resistance (due to natural rock or compacted fill on the face of footings)	2,000 psf*	1,000 psf*

* Passive resistance in the top foot should be neglected where footings are not confined on all sides by slabs or pavements.

Slab Floors

Floor slab subgrades should be rolled to provide a uniformly dense, nonyielding surface. Slab floors should be underlain by at least four inches of free-draining, crushed rock to provide a capillary moisture break. The rock should conform to the following gradation:

Sieve Size	Percent Passing
3/4 inches	100
No. 4	0 - 5
No. 200	0 - 3

An impervious membrane should be installed between the crushed rock and concrete slab where penetration of moisture vapor through the floor would be objectionable.

Pavement Design

We based the pavement thickness design on the City and County of Honolulu, "Design of Flexible Pavement" for residential subdivisions. We have assumed a California Bearing Ratio (CBR) value greater than 12. This value is based on our experience with similar tuff soils.

We recommend a pavement section of 2 inches of asphalt concrete and six inches of base course. Prior to placing the base course, the upper six inches of subgrade soil should be compacted to at least 95 percent relative compaction. The base course then should be placed and compacted to a field CBR of 85 percent. The quality, placement and compaction of the base and asphalt concrete should conform to the standards of the City and County Department of Public Works.

REVIEW OF PLANS AND CONSTRUCTION INSPECTION

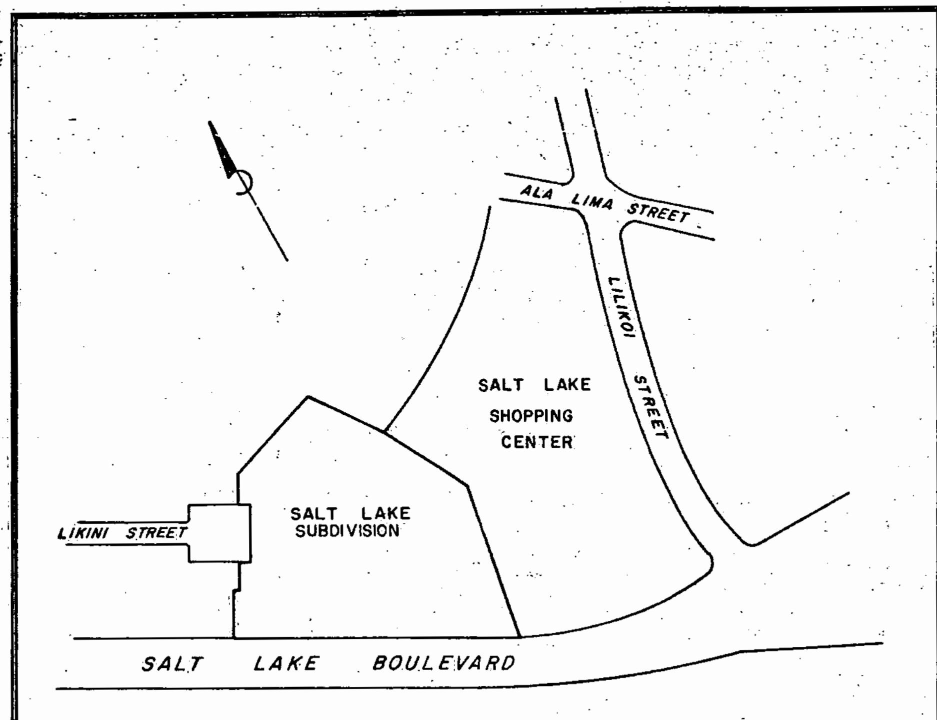
We recommend that we review the grading plans and specifications so that we can assist in correlating them with our recommendations. The site preparation, fill placement and foundation excavation should be performed under our soil engineering inspection. This inspection would permit us to check the quality of materials, perform compaction tests, and detect unanticipated field conditions that could require special treatment or modification of our recommendations. Special attention should be given to inspection of the cut slope during excavation.

PLATES

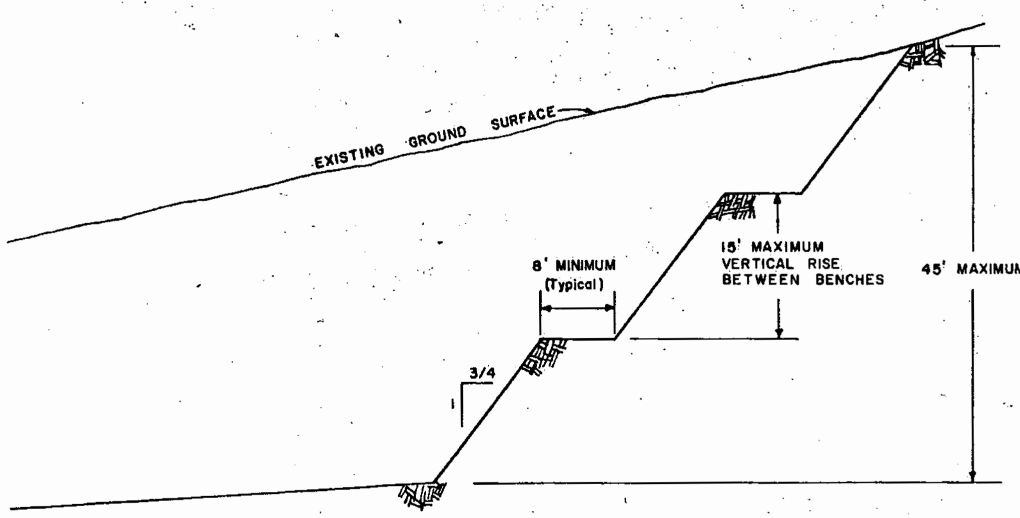
Plate	1	Site Plan
Plates through	2 4	Logs of Boring 1 through 3
Plates and	5 6	Logs of Tests Pits 1 through 3
Plate	7	Soil Classification Chart and Key to Test Data
Plate	8	Plasticity Chart
Plate	9	Compaction Test Data

DISTRIBUTION

4 copies	Midpac Development Company, Ltd. P. O. Box 1719 Honolulu, Hawaii 96806 Attention: Mr. Sam Shelton
1 copy	R. M. Towill Corporation 1600 Kapiolani Blvd. Honolulu, Hawaii 96814 Attention: Mr. Allen Young



LOCATION MAP
Not To Scale



TYPICAL SECTION
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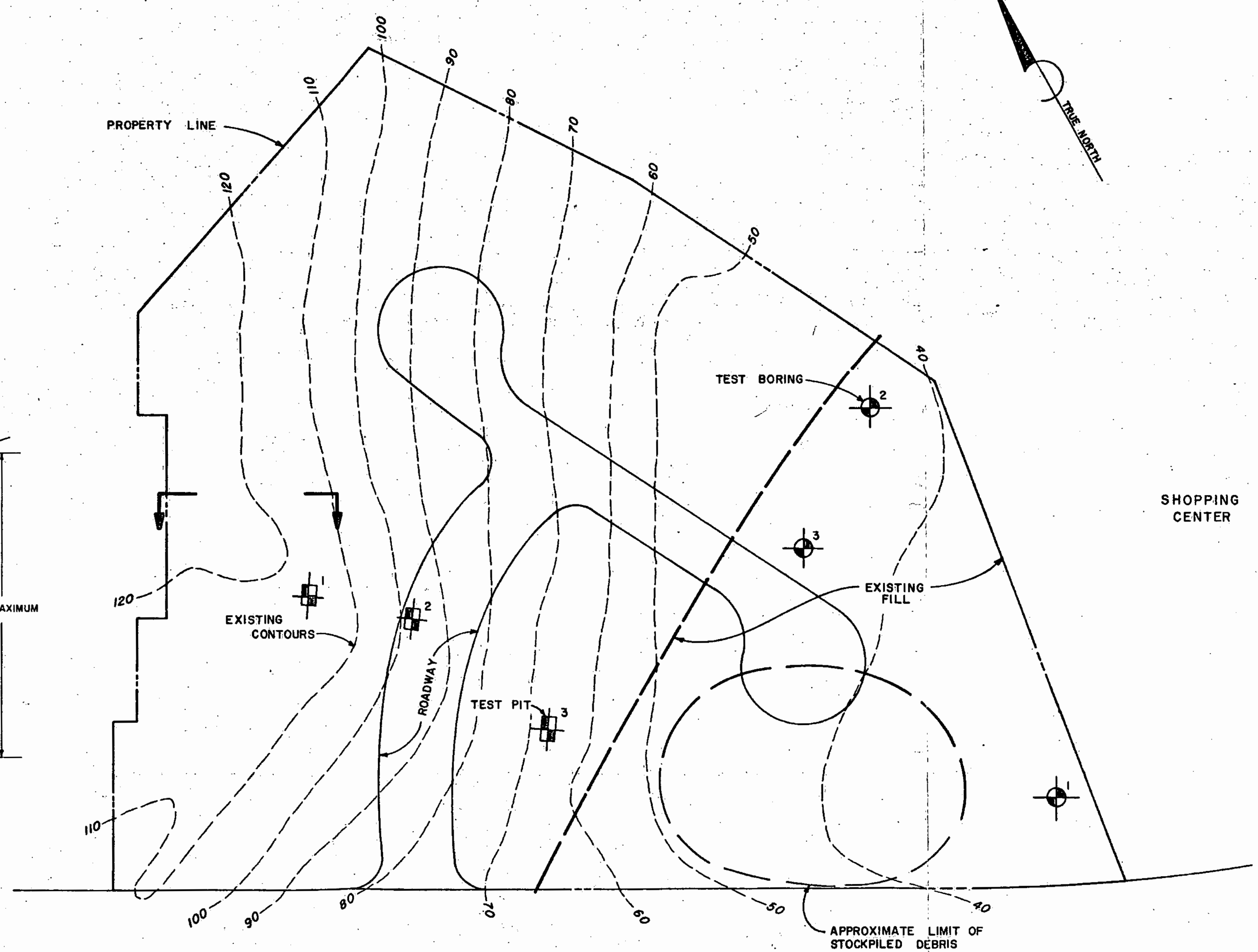
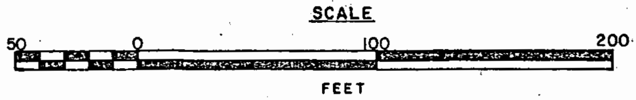


SCALE



Reference: Preliminary Subdivision of Lot 3406 by Allen C.H. Young, dated May 30, 1974.

Job No. 3992,001.06 Designed ___ Drawn FAC Checked HH Approved HH Date 8-27-74 Scale As Shown	HARDING - LAWSON ASSOCIATES *Consulting Engineers and Geologists*	**SITE PLAN** SALT LAKE SUBDIVISION HONOLULU OAHU HAWAII	PLATE 1

RF 14

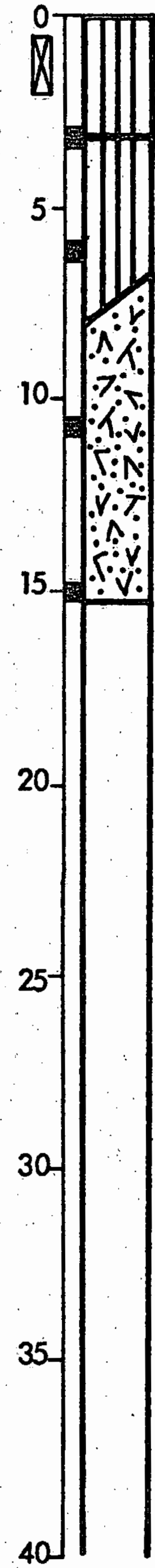
LOG OF BORING 1

Equipment 4" Flight Auger

Elevation 30* Date 7-31-74

Laboratory Tests	Drill Rate (min/ft)	Drill Pressure (psi)	Blows/foot	Moisture Content (%)	Dry Density (pcf)
Tx 1990 (1440)				36.5	77

Depth (ft) | Sample



DARK GRAY SANDY SILT (MH)
stiff, moist, with gravel and wood

DARK BROWN SILT (MH)
very stiff, moist

Fill

DARK BROWN TUFF
intensely fractured, low hardness, weak, deeply weathered (locally designated as mud rock)

No free water encountered

* Elevation Reference: Preliminary Subdivision of Lot 3406 by Allen C.H. Young, dated May 30, 1974

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LOG OF BORING 1
SALT LAKE SUBDIVISION
Honolulu, Oahu, Hawaii

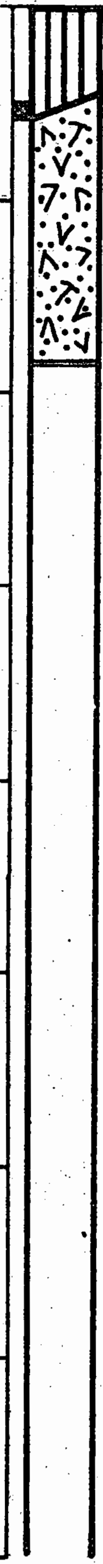
PLATE 2

LOG OF BORING 2

Equipment: 4" Flight Auger

Elevation: 42 Date: 7-31-74

Laboratory Tests	Drill Rate (min/ft)	Drill Pressure (psi)	Blows/foot	Moisture Content (%)	Dry Density (pcf)	Depth (ft)	Sample	Description
						0		DARK BROWN SILT (MH) very stiff, moist (Fill)
Tx 2050 (1152) Atterberg Limits Test LL=64, PL=39, PI=25				26.2	88			DARK BROWN TUFF intensely fractured, low hardness, weak, deeply weathered (locally designated as mud rock)
						5		
						10		No free water encountered
						15		
						20		
						25		
						30		
						35		
						40		



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LOG OF BORING 2

SALT LAKE SUBDIVISION

Honolulu, Oahu, Hawaii

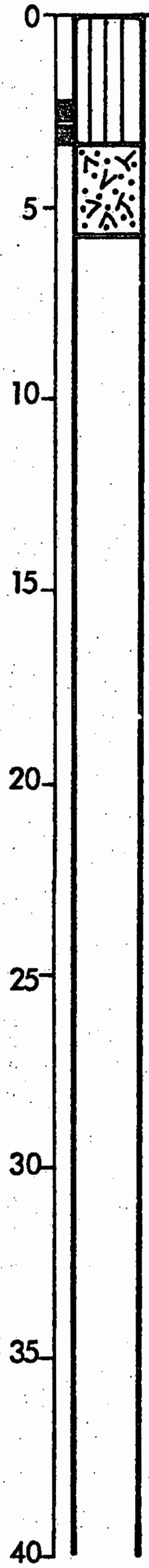
PLATE 3

LOG OF BORING 3

Equipment 4" Flight Auger

Elevation 43 Date 7-31-74

Laboratory Tests	Drill Rate (min/ft)	Drill Pressure (psi)	Blows/foot	Moisture Content (%)	Dry Density (pcf)	Depth (ft)	Sample



DARK BROWN SANDY SILT (ML)
medium stiff, moist — Fill

DARK BROWN TUFF
intensely fractured,
low hardness, weak,
deeply weathered
(locally designated
as mud rock)

No free water encountered

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LOG OF BORING 3
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PLATE 4

Laboratory Tests	Drill Rate (min/ft)	Drill Pressure (psi)	Blows/foot	Moisture Content (%)	Dry Density (pcf)	Depth (ft)	Sample

LOG OF TEST PIT 1

Equipment: Dozer

Elevation: 115 Date: 8/22/74

Depth (ft)	Description
0	BROWN SILT (ML) medium stiff, dry
	LIGHT BROWN-GRAY TUFF closely fractured, moderately hard, moderately strong, little weathered
5	(locally designated as mud rock)
10	
15	

LOG OF TEST PIT 2

Equipment: Dozer

Elevation: 95 Date: 8/22/74

Depth (ft)	Description
0	BROWN SILT (ML) medium stiff, dry
	BROWN TUFF closely fractured, low hardness, weak, deeply weathered
5	moderately hard, moderately strong, little weathered below 4.5'
	(locally designated as mud rock)
10	
15	

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LOG OF TEST PITS 1&2

SALT LAKE SUBDIVISION

Honolulu, Oahu, Hawaii

PLATE 5

LOG OF TEST PIT 3

Equipment: Dozer

Elevation: 65 Date: 8/22/74

Laboratory Tests	Drill Rate (min/ft)	Drill Pressure (psi)	Blows/foot	Moisture Content (%)	Dry Density (pcf)	Depth (ft)	Sample	Description
						0		BROWN SILT (ML) medium stiff, dry
								WHITE TUFF crushed, low hardness, friable, very deeply weathered
						5		LIGHT BROWN GRAY TUFF closely fractured, moderately hard, moderately strong, little weathered
						10		(locally designated as mud rock)
						15		
						20		
						25		
						30		
						35		
						40		

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LOG OF TEST PIT 3

SALT LAKE SUBDIVISION

Honolulu, Oahu, Hawaii

PLATE 6

MAJOR DIVISIONS				TYPICAL NAMES
COARSE GRAINED SOILS MORE THAN HALF IS LARGER THAN #200 SIEVE	GRAVELS MORE THAN HALF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE SIZE	CLEAN GRAVELS WITH LITTLE OR NO FINES	GW	WELL GRADED GRAVELS, GRAVEL - SAND MIXTURES
			GP	POORLY GRADED GRAVELS, GRAVEL - SAND MIXTURES
		GRAVELS WITH OVER 12% FINES	GM	SILTY GRAVELS, POORLY GRADED GRAVEL - SAND - SILT MIXTURES
			GC	CLAYEY GRAVELS, POORLY GRADED GRAVEL - SAND - CLAY MIXTURES
	SANDS MORE THAN HALF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE SIZE	CLEAN SANDS WITH LITTLE OR NO FINES	SW	WELL GRADED SANDS, GRAVELLY SANDS
			SP	POORLY GRADED SANDS, GRAVELLY SANDS
		SANDS WITH OVER 12% FINES	SM	SILTY SANDS, POORLY GRADED SAND - SILT MIXTURES
			SC	CLAYEY SANDS, POORLY GRADED SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN HALF IS SMALLER THAN #200 SIEVE	SILTS AND CLAYS LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS, OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC CLAYS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACIOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			Pt	PEAT AND OTHER HIGHLY ORGANIC SOILS

UNIFIED SOIL CLASSIFICATION SYSTEM

Shear Strength, psf
Confining Pressure, psf

Consol	— Consolidation	*Tx	320	(2600)	Unconsolidated Undrained Triaxial
LL	— Liquid Limit (in %)	TxCU	320	(2600)	Consolidated Undrained Triaxial
PL	— Plastic Limit (in %)	DS	2750	(2000)	Consolidated Drained Direct Shear
G_s	— Specific Gravity	FVS	470		Field Vane Shear
SA	— Sieve Analysis	*UC	2000		Unconfined Compression
■	"Undisturbed" Sample	LVS	700		Laboratory Vane Shear
☒	Bulk Sample				

Notes: (1) All strength tests on 2.8" or 2.4" diameter samples unless otherwise indicated.

(2) * Indicates 1.4" diameter sample.

KEY TO TEST DATA

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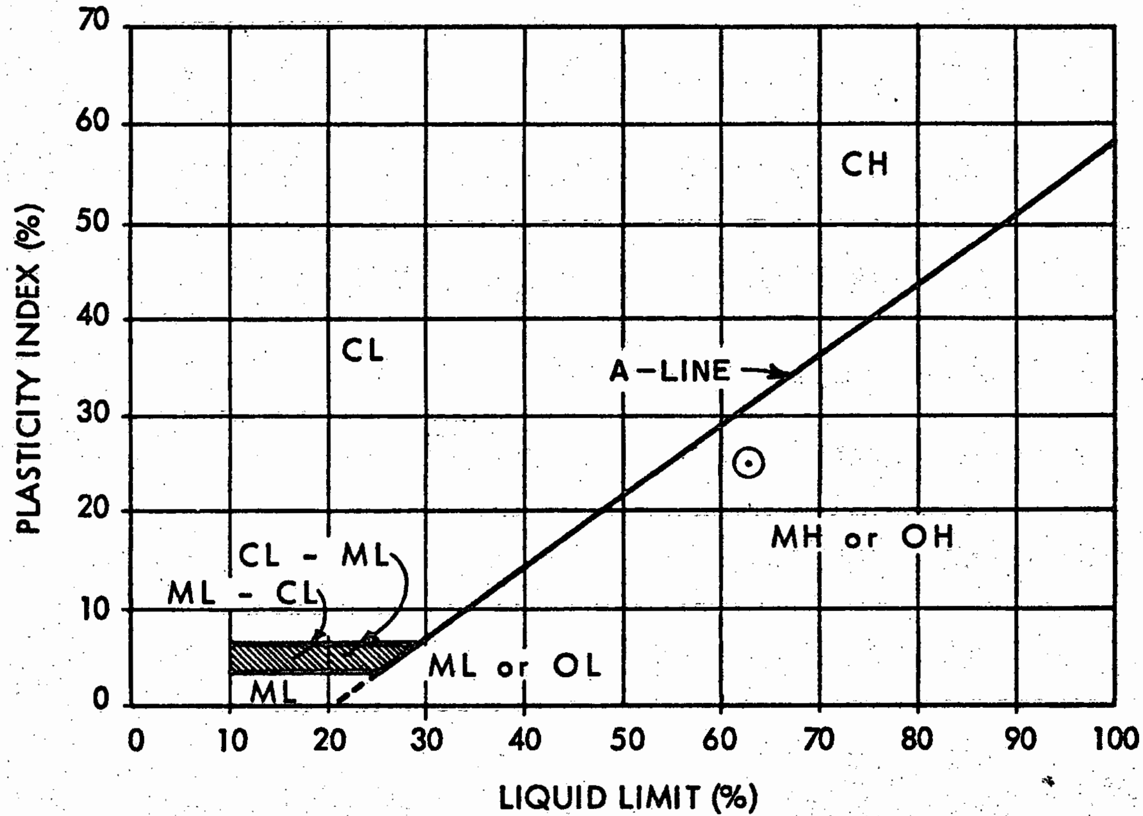
SOIL CLASSIFICATION CHART AND KEY TO TEST DATA
SALT LAKE SUBDIVISION
Honolulu, Oahu, Hawaii

PLATE 7

N02470



Symbol	Classification and Source	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% Passing #200 Sieve
⊙	DARK BROWN SILT (MH) Boring 2 @ 2.5'	64	39	25	

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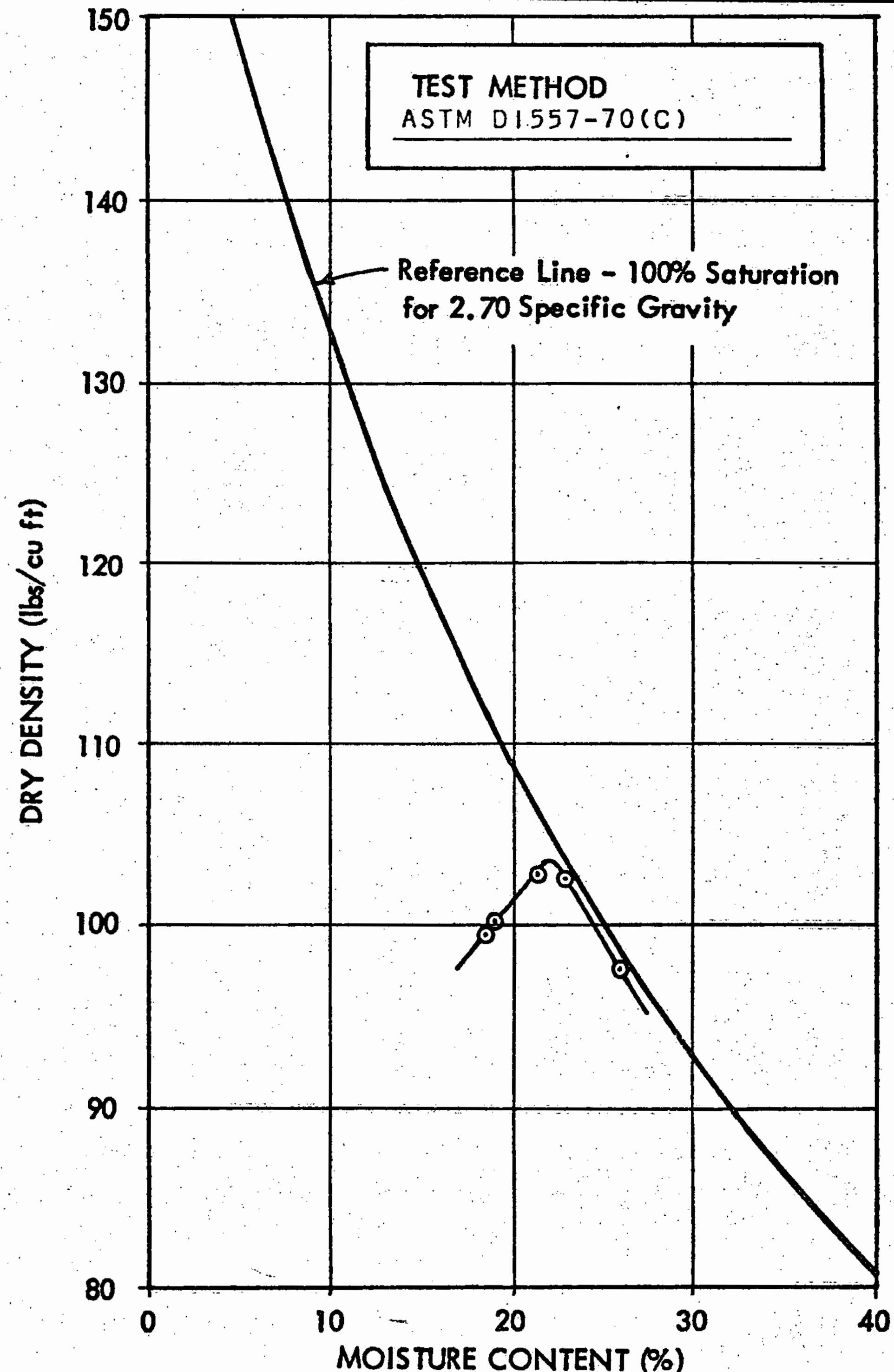
PLASTICITY CHART

SALT LAKE SUBDIVISION

Honolulu, Oahu, Hawaii

PLATE **8**

N02470



Symbol	Sample Source	Classification	Optimum Moisture (%)	Maximum Dry Density (pcf)
⊙	Boring 1 @ 0.5' to 2.0'	DARK GRAY SANDY SILT (MH)	22.5	103

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COMPACTION TEST DATA
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PLATE 9